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Assessment of Atlantic herring in NAFO Division 4T, 1986

by

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ABSTRACT

Reported herring landings in 1985 in the southern Gulf of St. Lawrence (NAFO Division 4T) were 31,288 t. Unreported landings were estimated to be another 9,000 t. Catch rates in the 1985 gillnet fishery indicated that stock abundance was similar to 1984 for the spring fishery, but higher than the previous 12 years for the fall fishery. Fishing mortality on fully-recruited age groups was estimated to be 0.30 for spring spawners and 0.25 for fall spawners. In both spawning groups the 1979 and 1980 year-classes comprised over 50% of the 1985 catch biomass. Projected landings at $F_{0.1}$ = 0.3 for 1987 are 7,500 t for spring spawners and 24,000 t for fall spawners.

RESUME

L'on a signalé que les débarquements de harengs dans la partie sud du golfe du Saint-Laurent (division 4T de l'OPANO) ont été de 31 288 t en 1985. L'on a estimé à environ 9 000 t les débarquements non signalés. Les taux de prise au filet maillant en 1985 indiquent que l'abondance des stocks était comparable à celle de 1984 pour la pêche du printemps, mais supérieure à celle des 12 années antérieures pour ce qui est de la pêche d'automne. La mortalité due à la pêche chez les classes d'âge entièrement recrutées a été estimée à 0,30 pour les géniteurs du printemps et à 0,25 pour les géniteurs d'automne. Dans ces deux groupes en phase de frai les classes d'âge de 1979 et de 1980 représentaient plus de 50 % de la biomasse des captures de 1985. Pour 1987 les débarquements projetés à $F_{0,1}$ = 0,3 sont de 7 500 t pour les géniteurs du printemps et de 24 000 t pour les géniteurs d'automne.

1. INTRODUCTION

This assessment of the 1985 herring fishery marks the tenth occasion that CAFSAC has provided biological advice on 4T herring. There have been ten previous assessments, including: Winters et al. (1977), Winters (1978), Winters and Moores (1979), (1980), Cleary (1981), (1982), (1983), Ahrens and Nielsen (1984), Ahrens (1985a), and Clay and Chouinard (1986).

Because of uncertainty regarding the index of stock abundance, two assessments were required for the 1984 fishery (Ahrens 1985a, Clay and Chouinard 1986). One objective of this assessment, therefore, is to develop an acceptable index of stock abundance.

Previous assessments have described the complexity of the 4T herring fishery; three major factors stand out. First, there are at least two major spawning groups: spring and fall spawners. Identification of these spawning groups in samples from commercial fisheries was based on an analysis of morphometric and meristic traits (Parsons 1975). Some recent evidence based on morphometry of otoliths suggests that there may be a third group, the summer spawners (Messieh and MacDougall 1984), but this group is not identified in this assessment.

Second, there are two major types of gear used to fish for herring in the southern Gulf of St. Lawrence: gillnets and purse seines. In 1985, about 87% of the catch was taken in gillnets, of which 60% was taken in fixed gillnets; the remaining 40% was taken in drift gillnets. Gillnets are set inshore, primarily on the spawning grounds. By contrast, purse seines, which took the remaining 13% of the 1985 catch, are fished offshore. Purse seines capture a mixture of stocks and generally catch younger and smaller fish than gillnets. A small precentage of herring was caught in traps and miscellaneous gears, but because these gears are set inshore their landings have been included with gillnets.

Third, herring are fished at various locations throughout the 4T area of the Gulf of St. Lawrence. In general, it is assumed that this spatial separation is of less significance than time of spawning. Although it should be mentioned that variation in morphometric and meristic traits among areas within spawning groups was as great as that found between the spring and fall spawning groups (Parsons 1975).

Quotas or total allowable catches (TAC) have been established since 1972 (Figure 1). From 1974-81, the TAC ranged from 45,000 to 60,000 t but it was never achieved. From 1981-84, the TAC ranged from 15,000 to 20,000 t but was exceeded each year by at least 30%.

In 1985, the TAC was 32,500 t, and the recorded landings indicate that it was almost achieved, but unreported landings indicate that it was exceeded by about 30% (see Section 2.1). The 1985 TAC was divided as follows: 6,000 t for the spring gillnet fishery; 20,000 t for the fall gillnet fishery; and 6,500 t for the fall purse seine fishery. For the 1986 fishery, it was recommended that the TAC should be 25,000 t: 9,000 t for spring spawners, and 16,000 t for fall spawners (CAFSAC Advisory Doc. 86/1-Anon 1986).

2. INPUT DATA

2.1 Landings

Nominal catches for 1984 and 1985 were revised slightly from the previous year. The 1984 landings from Gulf Region were revised by Statistics Branch on April 21, 1986. The 1984 landings from Quebec Region, 1933 t, are as presented by Ahrens (1985a). The 1985 landings included recent estimates from Statistics Branches in Gulf, Scotia-Fundy and Quebec regions. A seizure of 1473 t from the inshore fishery in NAFO Unit Area 436 (Figure 2) was included in the official landings.

The following general points can be made with reference to the 1984 and 1985 nominal catches. First, the largest monthly catch was taken in September (Table 1): in 1984, 30% of the annual catch was taken in this month; and in 1985, it was 50%. Second, two thirds of the catch was taken in the fall gillnet fishery which had its largest catch since 1971 (Table 2). Third, the fall 1985 purse seine catch was equal to the mean 1981-84 catch, but only 13% of the mean 1971-80 catch. Fourth, the 1985 purse seine catch was entirely in October and November (Table 3). Fifth, about 10% of the 4T catch was landed in Quebec (Table 3).

In 1985, 4% of total landings were officially recorded on Supplementary-B slips (slips filled out monthly by fishery officers to estimate landings not sold to plants): 1148 t from the spring fishery (January-June), and 239 t from the fall fishery (July-December). The proportion of catch recorded on Supplementary-B slips was not known for earlier years.

Because it is generally assumed that Supplementary-B slips cover only a small fraction of landings not sold to plants, an attempt was made to estimate these unreported landings from a survey of fishermen in 1985 (Nielsen 1986). Eight fishery areas were identified in the survey (Table 4). The greatest fraction of unreported landings occurred in the Acadian Peninsula and Escuminac areas. Unreported catches increased the landings in the spring fishery by almost twofold, but there was only a 25% increase of landings in the fall fishery. Overall, landings were 40,842 t or 30% greater than the nominal catch. The assessment was not calculated with this revised estimate because it was not possible to adjust earlier years.

2.2 Abundance Index

Four types of abundance indices were calculated: catch rates in the gillnet fishery, catch rates in the purse seine fishery, catch rates in research vessel surveys, and spawning bed surveys of egg biomass.

2.2.1 Gillnet fishery catch rates:

Two types of catch rates were calculated for the gillnet fishery: catch per trip, and catch per net per trip. The first, catch per trip, was estimated from purchase slip data. This catch rate has two problems, first, each purchase slip is assumed to equal one successful fishing trip and therefore, it underestimates actual effort by not accounting for unsuccessful trips. Second, only catches landed at processing plants are recorded on

purchase slips, and they do not account for herring sold locally or used as bait.

Catch per trip data are available on a monthly basis, 1973-85, for five areas (Figure 3): Caraquet (Statistical Districts (S.D.) - 65, 66, 67), Escuminac (S.D. - 73, 75), Shediac (S.D. - 78, 80), Pictou (S.D. - 11), and North P.E.I. (S.D. - 82, 92). These areas were selected because they are areas of major gillnet landings and because most of their catch is from discrete spawning aggregations (Messieh 1984). For the spring fishery, average landings from these five areas were 53% of inshore gears and 36% of total landings in Division 4T (Table 5). For the fall fishery, 58% of inshore catches and 27% of total catches were from these five areas. In 1983-85, 80% of spring catches and 50% of fall catches were from these areas (Table 5).

The annual catch per trip for each area is summarized in Table 6; 1973-83 data were taken from Messieh (1984). There were no correlations over time of catch rates between areas within the spring fishery, and only one significant correlation ($p=0.03$) between Escuminac and Pictou in the fall fishery. This result suggested that, within fishing season, stock abundance was independant in each of the five areas. There were several significant correlations between fishing seasons, however, which suggested that the areas were not independent. For example, the spring Escuminac fishery was negatively correlated with the fall Escuminac fishery ($p=0.008$); and positively correlated with the fall Pictou fishery ($p=0.02$); and the spring Shediac fishery was negatively correlated with the fall Escuminac fishery ($p=0.04$), and positively correlated with the fall Shediac ($p=0.01$) and fall P.E.I. ($p=0.02$) fisheries. This result suggested that Caraquet stocks were different from the others and that Shediac, Escuminac, Pictou and P.E.I. stocks had migration routes which were more similar.

The monthly catch rate data were analyzed by area, month and year, separately for the spring and fall fisheries, using the multiplicative model of Gavaris (1980) in a revised STSC APL version written by D. Gascon, Quebec Region (STANDARD.WS Version 1.0). For the spring fishery, 35% of the standardized catch rate could be explained by the model, due to variation among areas and months (Table 7). There was no significant annual variation or trend in the standardized catch rate (Figure 4). Similar results were obtained for the fall fishery (Table 7, Figure 4) and the standardized catch rates were not used as an index of abundance for either fishery.

Daily catch rate data for gillnets were also available by Statistical Districts for 1978-85. Statistical Districts 11, 65, 66, 67, 73, 87 and 92 were selected to calculate a standardized, bi-weekly catch rate for the spring and fall fisheries using the multiplicative model. These districts were chosen because they had the greatest landings of all Statistical Districts in Division 4T. There was significant annual variation in the standardized catch rate for both spring and fall fisheries (Table 8). In both fisheries, the 1985 catch rate was significantly higher than previous years (Figure 5). The regression for the fall fishery which was threefold better than that for the spring fishery, indicated an increasing trend in catch rate since 1978 (Figure 5). Because this data set covered only eight years, it was not used as an index of abundance for either fishery.

The second catch rate for gillnets included the catch per trip from purchase slip data, but also accounted for the number of nets used to fish for herring (Table 9). The number of nets was estimated from a series of four questionnaires which were sent to fishermen in recent years:

Years Surveyed	Year of Survey	Reference
1971-79	1978-79	O'Boyle and Cleary (1981)
1980-82	1983	Cleary, unpublished
1983	1984	Ahrens, unpublished
1983-85	1985	Nielsen (1986)

Several points should be made about the consistency of this time series. First, O'Boyle and Cleary (1981) estimated the number of nets used per fishing trip in the spring fishery by weighting annual estimates from two large areas, Chaleur (S.D. 63-68) and Escuminac (S.D. 70, 73, 75-78, 80, 82, 83, 92), by the number of fishermen surveyed in each area. This weighted average was used in all assessments until 1985 when Clay and Chouinard (1986) weighted the average nets per trip by the proportion of catch in the two areas. We continue to use their modification.

Second, the questionnaires cover a broader area and more Statistical Districts than included in the time series of catch rates taken from Messieh (1984) - see Table 9. Because there was considerable overlap of Statistical Districts in both data sets, this potential source of error was not considered important.

Third, the time series of nets per trip must be consistent with the type of fishermen surveyed, and until this assessment, it was not. For example, O'Boyle and Cleary (1981) estimated nets per trip for only those fishermen who sold more than 50% of their catch to fish plants, whereas in recent surveys nets per trip were calculated for all fishermen (Nielsen 1986). This distinction is important because in Escuminac area, fishermen who sold their catch to plants used 31.3 nets per trip while those who kept their catch used 16.0 nets per trip (O'Boyle and Cleary 1981). In 1979, 57% of catch in Escuminac was sold to plants. In Chaleur area, there was little change in the number of nets per trip between fishermen who sold (6.6 nets) and those who kept (5.4 nets) their catch.

Because the type of fishermen was not known for all years, we adjusted recent data to be respresentative of fishermen who sold $>50\%$ of their catch to plants. For the years 1980-82, unpublished data (kindly provided by L. Cleary, Quebec Region) were analyzed and the average nets per trip were as follows, (previous values from Clay and Chouinard (1986) are included for comparison):

Year	Spring Fishery		Fall Fishery	
	Clay & Chouinard	New Data	Clay & Chouinard	New data
1980	31.5	39.2	11.0	18.4
1981	35.9	41.4	11.0	19.3
1982	35.4	39.7	11.0	18.6

In Table 9, it is clear that these revised catch rates were high in comparison to previous years but because they were based on an extensive survey of many fishermen they were used in this assessment.

The number of nets per trip for 1983-85 was estimated from the survey results of Nielsen (1986). In the 1985 spring fishery, it was known that fishermen who sold > 50% of their catch to plants used 27.0 nets per trip, whereas an average for all fishermen was 22.8 nets per trip, a difference of 19%. This percentage was used to adjust the old values for the spring fishery as indicated below:

Year	Old (all fishermen)	New (sell > 50%)
1983	18.9 nets/trip	22.5 nets/trip
1984	22.2	26.5
1985	22.8	27.2

The catch per net per trip 1973-85 in the spring and fall fisheries, which were the catch rates used as an index of stock abundance in this assessment, are presented in Table 9. Values in the fall fishery were updated but not changed from Clay and Chouinard (1986); they were significantly correlated ($p < 0.01$) with results from the multiplicative model (monthly purchase slip data) (Fig. 6). The spring catch rate showed a similar trend to the multiplicative model but they were not correlated.

Because the survey by Ahrens (1983, unpublished) was designed to calculate the distribution of mesh sizes and not the numbers of nets fished per trip, it was not used in this assessment.

The number of nets was also estimated in 1980, 1981 and 1983 from aerial surveys. These surveys were conducted in three areas, Caraquet, Escuminac, and North P.E.I. in each year. The mean number of nets each year was calculated by weighting the count in each area by the landings. As can be seen below, the trend in number of nets estimated from the aerial survey corresponds well to that from the questionnaires sent to fishermen:

Year	Aerial Survey (mean no. nets)	Questionnaire (nets/trip)
1980	35,577	31.5
1981	43,391	35.9
1982	--	35.3
1983	25,642	22.4

2.2.2 Purse seine fishery catch rates:

Catch rates (tonnes per set) in the purse seine fishery were available from logbooks sent annually to Statistics Branch by the fishermen. These data were summarized by month 1971-79 by Winters and Moores (1980) who used an unweighted mean as the best index of an annual catch rate. Logbooks from 1980-85 were summarized and the unweighted mean was calculated as before (Table 10). The unweighted mean was significantly correlated (P 0.01) to the catch per net per trip in the fall gillnet fishery (Table 9). Because only about 10% of landings are taken by this fishery, this catch rate series was not used as an abundance index.

2.2.3 Research vessel surveys:

Catches of herring in the E.E. Prince bottom trawl surveys, 1970-85, are incidental and therefore, catch rates from this time series should be viewed with caution. A computer program, RVAN (Clay, unpublished), was used to analyze the historical research vessel data and to calculate the mean biomass of herring caught at fixed and random stations in NAFO Division 4T. These data are presented in Table 11; they did not correlate with any other index of abundance but two points were clear: In 1984-85, the mean biomass was higher than other years since 1971; and in 1985, herring were found in more strata than in any other year.

2.2.4 Spawning bed surveys:

Surveys of egg deposition rates were conducted in 1980, 1981, 1983, and 1984 on the spawning beds located near Escuminac in Miramichi Bay. These are the most extensive spawning beds of spring spawners in the Gulf of St. Lawrence. The number of eggs is estimated from randomly sampled quadrats of substrate using SCUBA. The 1980 survey was not as complete as the other years but it is included below for comparison:

Year	Total No. of eggs (x108)	Spawning stock biomass (t)	Reference
1980	9.0	5.3-6.4	Pottle et al. 1980
1981	0.7	1.0	Messieh, unpublished
1982	-	-	-
1983	217.1	151.3	Messieh et al. 1983
1984	1687.0	2837.2	Messieh et al. 1985

The natural logarithm of the number of eggs was significantly correlated with the catch rate ($p=0.03$) in Escuminac during the same year (Table 6). It was also noteworthy that the exploitation rate on these spawning beds was 84-97% of the spawning population in 1983 (Messieh et al. 1983) and 59% in 1984 (Messieh et al. 1985).

2.3 Catch and Weight at Age

In 1985, the sampling of herring in the commercial fishery was changed from random to stratified, or two phase, sampling. This change was necessary because stratified samples of herring are more efficient to collect than random samples and because they are compatible with samples taken for other species. In the past, samples for ageing were taken randomly at various times and locations from the commercial fishery; these samples alone were used to construct the catch-and weight-at-age matrices. In 1984, both random and stratified samples were collected. The stratified samples comprised detailed samples for each 1 cm interval and a larger sample of 250 fish for length-frequency data. Ahrens (1985b) demonstrated that age structure and mean weight at age were not significantly different between random and stratified sampling. The number of detailed samples collected in 1985 and previous years is summarized in Table 12.

Spawning group for each sample was assigned by a discriminant function based on otolith morphometry (Messieh and MacDougall 1984). If the probability of the discriminant function was 65% and the maturity stage of gonads was between 5 and 7 (Cleary et al. 1982), the fish sampled was assumed to spawn during the fishing season that it was captured. In previous years spawning group was assigned by maturity stage of gonads but it was not possible to use gonads from 1985 samples because of deterioration during freezing. As in previous years, the annulus was assumed to be formed on January 1 of each year, thus a fish hatched in September becomes a one year old four months later.

Catch-and weight-at-age matrices were calculated using stratified samples for both spring and fall spawning groups in 1984 and 1985. Revised values were required for 1984 because of a slight increase in the nominal landings from Clay and Chouinard (1986). Gillnet fisheries in NAFO Division 4T were divided into three groups for each spawning group, including: NAFO Unit Areas 431-4, Areas 436, and Areas 437-9. These areas were further subdivided into the spring (Jan.-June) and fall (July-Dec.) fisheries. A seventh group included all fish taken by purse seines. A computer program called HERCTA was used to combine the age-length keys and length-frequency data within each group and to weight the numbers at age by the landings. The numbers at age were summed to a total for each spawning group. The percentage of the catch by spawning group in the spring and fall fisheries, 1980-85 are summarized in Table 13. The percentage of fall spawners in the fall gillnet fishery for areas 437-439 was 87% in 1985 but it was 96-100% in 1981-84 (Table 13). Thus there appears to have been a redistribution of spawners in 1985, or perhaps a problem with assigning spawning group.

In the 1985 assessments (Ahrens 1985a, Clay and Chouinard 1986), 1981-84 average mean weights were used in the weights-at-age matrix of spring spawners, 1977-84; for fall spawners the 1981, 83, 84 average mean weights at

age were used. The 1985 mean weights were significantly different from these average mean weights (Table 14): fall spawners in 1985 were significantly ($P < 0.05$) heavier at ages 3-11; and spring spawners in 1985 were significantly lighter at ages 3-6, and heavier at ages 7-8. Because of these differences the 1981-84 average mean weights were used only for the years 1977-80, and the actual mean weights were used for 1981-85. The mean weight-at-age matrix for spring and fall spawners, 1974-85 is shown in Table 15.

The catch-at-age matrix was calculated separately for spring and fall spawners in the gillnet and purse seine fisheries (Table 16). It was truncated at age 11+ to be consistent with previous assessments (Clay and Chouinard 1986). The most striking difference between 1985 and previous years was the small numbers of age 2+ herring caught in the spring fishery. The cross products of the 1985 mean weights and catches at age were within 2% of the reported catch.

The landings in the gillnet fishery by spawning group (cross products of Tables 15 and 16) were divided by the catch rate (catch/net/trip of Table 9) to obtain an effort index (Table 17). This effort index was used to calibrate the VPA.

2.4 Partial Recruitment

Initially, partial recruitments (PR) for the spring and fall fisheries were calculated in the same manner as Clay and Chouinard (1986). The essential steps in their calculation are as follows: selectivity curves were known for mesh sizes of 2.25, 2.50, 2.63, and 2.75 inches (Ahrens 1985a); curves for eight other mesh sizes, ranging from 1.63 to 3.25 inches, were interpolated and extrapolated using the average variance, skewness and kurtosis of Ahren's curves and the Gram Charlier series; selectivity at age was obtained by multiplying the selectivity at length by the age-length key; 1985 gill net landings were separated according to mesh size (Table 18) using Nielsen's (1986) survey of fishermen; the combined selectivity at age was weighted by landings at each mesh size for the spring and fall fisheries; immature fish were assumed to be not on the spawning grounds; and, maturities at age in the gillnet fishery were assumed to be:

	2	3	4	5	6
Spring	0	0.5	0.8	1.0	1.0
Fall	0	0.1	0.6	1.0	1.0

Selectivity at age for the purse seine fishery was assumed to be 1.0 for age 3 and older; 50% of purse seine catches were assumed to be spring spawners; and finally, purse seine and gillnet catches at age were combined and normalized at the age with the highest catch. The partial recruitment values used in the current and past two assessments are summarized in Table 19. It is noteworthy that if selectivity of the purse seine fishery was assumed to be 1.0 for age 2 and older, partial recruitments at age 2 would become 0.44 for the spring spawners and 0.15 for fall spawners.

For several reasons these partial recruitment values were changed. First, PR at age 2 was changed to 0.001 to be consistent with the small catches of two year old herring taken by the fishery. Second, in the fall

spawning component it was evident from the table of historical F values (Table 21) that partial recruitment had never been dome-shaped. In all years, F values were greatest in the older age groups. Therefore fall spawners were assumed to be fully recruited to the fishery after age 5. This flat-topped recruitment curve produced the best calibration plots for tuning the VPA. Third, for spring spawners it was assumed that both ages 4 and 5 were fully recruited. This change was consistent with the trend in F values for the 1980 year-class (Table 20) and it also produced better calibration plots for tuning the VPA than did a PR of 0.72 at age 5 or a PR of 1.00 at ages 4, 5 and 6. The PR values used in this assessment are presented in Table 19.

2.5 Natural Mortality

As in previous assessments natural mortality was assumed to be 0.2.

2.6 Fishing Mortality

2.6.1 Oldest age F:

This mortality rate was calculated at a selected terminal F using the iterative technique of I. McQuinn and G. White (unpubl.) assuming that the F on the oldest age (in this case the 11+ group) was the same as the F on the 2nd oldest. Thus the catch matrix was then handled as though it ended at age 10 and subsequent calculations were carried out on the 11+ group which were then added to the results (see Clay and Chouinard 1986 for an APL program listing).

2.6.2 Terminal F:

The annual gillnet catch of spring and fall spawners separately (Table 16) was divided by the seasonal gillnet catch rates (Table 9) to estimate the annual gillnet effort index for each spawning group (Table 17). The fully recruited F for the last year was chosen on the basis of regressions between spawning group gillnet catch biomass at age per unit effort and estimated VPA spawning group population at age. The VPA was run using the APL workspace FISH, Version 1.0 written in WATCOM APL (Rivard 1982). The selection criteria were based upon maximizing the coefficient of correlaton (R2) and minimizing the sum of squared standardized ((observed-expected) ÷ expected) residuals of the last four years (1982, 1983, 1984, and 1985). This was repeated individually for ages 4, 5 and 6 for spring spawners and 5, 6 and 7 for fall spawners for the years 1974 to 1984. It was assumed that fishing was incomplete on the oldest age groups when running the VPA's. The VPA's were calculated assuming mid-year numbers and weight for spring spawners and end of year values for fall spawners.

3. ASSESSMENT RESULTS

3.1 Spring Spawners

The fully recruited F in 1985 was estimated to be 0.30. Calibration plots at this fishing mortality are shown in Fig. 7a) b) and c). The population numbers calculated for spring spawners are shown in Table 20. The most striking feature in recent years is the large size of the 1979 and 1980

year-classes. The 1979 year-class dominated for the fourth consecutive year. The 1980 year-class was also above average. Together, these two year-classes comprised over 50% of the catch biomass.

3.2 Fall Spawners

The fully recruited F in 1985 was estimated to be 0.25. Calibration plots at this F are shown in Figure 7d) e) and f). Again the 1979 and 1980 year-classes dominated, together they comprised 55% of the catch biomass. Historical population biomasses and fishing mortalities are presented for both spawning groups in Table 22.

4. PROGNOSIS

The 1985 numbers at ages 2 and 3 were set at the geometric mean levels for the period 1974 to 1982. Projections were made using the following: 1974-82 geometric mean at age 2; expected catches in 1986; and the fully-recruited F's at $F_{0.1}$. The catch in 1986 was assumed to be 9,700 t of spring spawners and 15,300 t of fall spawners. This catch was estimated assuming that all fish would be caught in the proposed allocation: for spring spawners, 7,200 t in spring gillnet fishery and 2,500 t in fall purse seine fishery; and for fall spawners, 12,800 t in fall gillnet fishery and 2,500 t in fall purse seine fishery. Partial recruitment and mean weights in the period 1986 to 1989 were assumed to be as estimated for the 1985 fishery. The results were as follows:

Spring spawners	1986	1987	1988	1989
Catch (t)	9,700	7,500	8,000	8,300
4+ biomass (t)	26,300	26,800	28,100	28,900
Fully recruited F	0.41	0.30	0.30	0.30
Recruitment ('000s)	96,300	96,300	96,300	96,300
Fall spawners				
Catch (t)	15,300	23,800	21,500	19,800
4+ biomass (t)	96,600	89,200	84,200	76,300
Fully recruited F	0.18	0.30	0.30	0.30
Recruitment ('000s)	139,300	139,300	139,300	139,300

These projected catches rely heavily upon a few recently recruited year-classes and particularly upon one large year-class for each spawning component. Population biomass of the spring component remains low compared with that of 15 years ago and without strong recruitment it is not expected to increase substantially in the near future. It is noteworthy that 30% of the spring component is captured in the fall fishery.

The projected catches at $F_{0.1}$ level in 1987 are 23,800 t for the fall spawners and 7,500 t for the spring spawners. A summary of projections until 1992 is presented in Table 23.

Projections based on partially recruited age groups are prone to large errors. In the spring component more than 50% of the catch projection for 1987 was based on ages which were not fully recruited in 1985. This proportion was 35% for the fall component.

5. RESEARCH NEEDS

There are five problem areas which need to be addressed during the next year. First, the accuracy and timeliness of landings statistics should be improved. In 1985, it was estimated that 50% of landings in the spring fishery were not reported.

Second, there is a need to establish reliable indices of stock abundance. In the short term, the fishermen's questionnaire should be continued and improved to detect bias in the response of participants. Historical landings and effort statistics should be validated and documented. In the long term, an experimental gillnet program should be initiated. Fishermen involved in this program could be used to obtain information on catch rates, recruitment of younger age groups, and biological samples.

Several independent estimates of stock abundance should be investigated further including: surveys of spawning beds, in particular to locate the size and extent of these beds; and secondly to examine the feasibility of using acoustic surveys to estimate recruitment of young age groups.

Third, the catch-and weight-at-age matrices, 1974-85 need to be reconstructed.

Fourth, there is a need to validate the use of otoliths as a means of assigning spawning group. Validation should be done without prior knowledge of sampling date or fish length and the results should be compared to the traditional method of gonad assignment.

Fifth, information relevant to the occurrence of 4T stocks in NAFO Divisions 4RS and 4Vn needs to be summarized. Tag recaptures should be weighted by effort in areas from which tags were returned.

Finally two alternatives to the quota system should be considered. First, it appears that a limit should be set upon the number of nets set per trip or perhaps a quota per fisherman. These measures might prevent excessive fishing mortalities in years of low stock abundance. Second, a closure of one or two days per week in the gillnet fisheries might allow sufficient spawning escapement without unduly restricting the fishery.

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Table 1. Herring landings in NAFO Division 4T, 1967 to 1985 (t).

YEAR	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
1967	1742	--	--	409	25220	8764	5679	10718	4620	1358	3095	1131	62736
1968	546	442	806	6455	24239	2566	15847	19768	22350	5284	13057	770	112130
1969	--	--	73	9329	17701	6568	35476	46987	22448	4169	11543	121	154415
1970	--	55	--	21211	15782	2545	51002	36860	24959	18506	3831	746	175497
1971	--	--	42	10644	11895	4809	41521	23067	36282	5163	1053	370	134846
1972	--	--	--	400	6102	2583	11034	9092	14453	7777	2108	41	53590
1973	--	--	--	1876	12801	4221	2135	7737	9436	2079	69	3	40357
1974	--	--	--	1302	14474	1190	2958	3143	7282	3081	1714	9	35153
1975	--	--	--	4028	20229	1428	289	2398	4646	8986	2256	305	44565
1976	--	--	--	8461	14406	961	193	1082	1807	5244	6973	326	39453
1977	--	--	--	7625	8338	8850	244	2125	1148	7166	8726	602	44824
1978	240	--	--	2046	13363	883	526	2487	10095	13672	6981	2848	53141
1979	--	--	--	14072	6158	1113	680	1766	6381	5071	9904	2598	47743
1980	80	--	15	10458	9220	1032	910	2224	1952	9011	5001	540	40443
1981	--	--	13	1736	4566	729	1588	5119	3986	2171	1246	--	21154
1982	--	--	--	199	5667	876	442	5592	8047	3122	36	--	23981
1983	--	--	--	263	7282	1000	851	10291	2735	2160	1291	--	25873
1984*	--	--	--	188	5998	531	964	5747	8182	5433	184	--	27227
1985*	--	1	6	204	5237	577	776	5775	14675	3476	561	--	31288

*preliminary

Table 2. Catches (t) of herring by gear and by season in NAFO Division 4T 1971-1983. Spring fishery occurs from January to June; the fall fishery from July to December.

	GILLNETS (and other inshore)		SEINES (and other offshore)		
YEAR	SPRING	FALL	SPRING	FALL	TOTAL
1971	14074	10327	13316	97129	134846
1972	8137	9585	948	34910	53580
1973	11713	7920	7185	13539	40357
1974	8285	4199	8681	13988	35153
1975	7119	4741	18566	14139	44565
1976	6611	3419	17217	12206	39453
1977	4926	3285	19887	16726	44824
1978	8484	4853	8048	31756	53141
1979	7444	5780	13899	20620	47743
1980	6443	6784	13330	13886	40443
1981	6545	10926	20	3663	21154
1982	6742	14130	0	3109	23981
1983	8545	13858	0	3470	25873
1984*	6717	17701	0	2809	27227
1985*	6037	21566	0	3685	31288

*preliminary

Table 3. Preliminary monthly distribution of herring landings by area and gear type in NAFO Division 4T in 1985.

	MARITIMES		QUEBEC	
MONTH	Gillnets and inshore gears	Purse Seine	Gillnet and misc. gear	TOTAL
January	--	--	1	1
February	1	--	--	1
March	--	--	6	6
April	56	--	148	204
May	4652	--	585	5237
June	434	--	143	577
July	108	--	668	776
August	4998	--	777	5775
September	14235	--	440	14675
October	292	3126	58	3476
November	--	558	3	561
December	--	--	--	--
TOTALS	24776	3685	2827	31288

Table 4. Herring landings (t) by seasonal fishery for eight fishing areas in NAFO Division 4T. Estimated landings were calculated from results of a survey of fishermen in 1985 (Nielsen 1986). Statistical Districts within each area and given in parenthesis.

AREA	Spring		Fall	
	Reported	Estimated	Reported	Estimated
Magdalen Is. (26, 27, 28)	0	0*	0	0*
Quebec (3-15)	882	882*	1945	1945*
Acadian Peninsula (63-68)	650	2722	10349	11766
Escuminac (70, 71, 73, 75, 76)	2942	4846	17	17
Southeast N.B. (77, 78, 80)	1005	1305	48	48
Nova Scotia (1, 2, 3, 10-14, 45, 46)	192	192*	4549	4549
East P.E.I. (85-88)	32	32*	3636	3883
West P.E.I. (82, 83, 92, 93, 95, 96)	334	1202	1022	3768
TOTAL	6037	11181	21566	25976

* - Not adjusted

Table 5. Combined landings in Statistical Districts 11, 65, 66, 67, 73, 75, 78, 80, 82 and 92 as a percentage of landings in gillnets and other inshore gears and of total landings in NAFO Division 4T. Spring fishery includes landings from January to June; fall fishery includes landings from July to December.

YEAR	Percent of Gillnets and other inshore gears		Percent of Total landings in Division 4T	
	Spring	Fall	Spring	Fall
1973	48	69	30	26
1974	46	65	23	15
1975	33	70	9	18
1976	45	63	12	14
1977	40	66	7	11
1978	53	47	27	6
1979	51	41	18	9
1980	41	43	13	14
1981	35	59	35	42
1982	58	50	58	41
1983	77	59	77	47
1984	87	56	87	47
1985	71	68	71	59
Mean	53	58	36	27

Table 6. Catch-per-unit-effort (tons per purchase slip, or per successful fishing trip) in spring and fall inshore gillnet fisheries of five selected areas of NAFO Division 4T 1973-1985. The Statistical Districts represented by each area are given in the table heading.

YEAR	SPRING					FALL				
	Caraquet 65,66,67	Escuminac 73,75	Shediac 78,80	Pictou 11	PEI 82,92	Caraquet 65,66,67	Escuminac 73,75	Shediac 78,80	Pictou 11	PEI 82.92
1973	3.25	2.01	0.85	--	0.95	2.78	3.21	--	1.55	--
1974	2.15	1.58	0.45	--	0.36	6.20	3.71	--	0.97	0.21
1975	0.82	1.60	0.71	--	0.99	6.76	4.59	0.09	1.27	0.25
1976	1.52	1.83	0.24	--	0.49	5.18	7.44	--	1.04	0.44
1977	3.91	2.28	0.92	--	0.54	4.93	3.55	--	1.23	0.22
1978	4.33	2.67	1.22	--	0.96	4.18	4.30	--	1.05	0.38
1979	1.90	1.68	0.59	--	1.36	2.57	7.34	0.06	0.98	0.99
1980	2.56	1.17	0.63	--	0.92	1.78	5.37	--	0.85	2.69
1981	0.75	0.87	1.19	6.81	0.82	2.27	4.95	--	1.15	3.24
1982	1.49	2.33	1.28	9.46	1.61	4.00	1.25	--	0.74	5.28
1983	1.51	2.60	0.96	0.63	1.76	4.76	0.77	--	1.34	3.77
1984	1.33	2.92	0.62	--	0.44	3.52	0.77	0.75	2.83	2.46
1985	1.20	2.95	1.52	0.92	0.76	5.30	0.25	8.59	3.02	5.65

Table 7 Monthly catch rate (catch/trip) analyzed by area, month and year for the spring and fall fisheries.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .595
MULTIPLE R SQUARED..... .354

Spring

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Square	Mean Squares	F-Value
Intercept	1	7.132E-001	7.132E-001	
Regression	18	3.173E0001	1.763E0000	3.690
Type 1	4	1.706E0001	4.264E0000	8.925
Type 2	2	7.693E0000	3.846E0000	8.050
Type 3	12	7.914E0000	6.595E-001	1.380
Residuals	121	5.781E0001	4.778E-001	
Total	140	9.026E0001		

MULTIPLE R..... .645
MULTIPLE R SQUARED..... .416

Fall

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Square	Mean Squares	F-Value
Intercept	1	6.439E0000	6.439E0000	
Regression	19	1.069E0002	5.628E0000	6.298
Type 1	4	3.440E0001	8.600E0000	9.623
Type 2	3	5.761E0000	1.920E0001	21.490
Type 3	12	1.347E0001	1.123E0000	1.256
Residuals	168	1.501E0002	8.937E-001	
Total	188	2.635E0002		

Table 8 Daily catch rate (catch/trip) analyzed by area, month and year for the spring and fall fisheries.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .334
MULTIPLE R SQUARED..... .111

Spring

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Square	Mean Squares	F-Value
Intercept	1	2.673E-002	2.673E-002	
Regression	17	9.589E0001	5.641E0000	4.372
Type 1	7	2.385E0001	3.407E0000	2.641
Type 2	3	1.860E0001	6.200E0000	4.806
Type 3	7	3.526E0001	5.038E0000	3.905
Residuals	593	7.650E0002	1.290E0000	
Total	611	8.609E0002		

MULTIPLE R..... .567
MULTIPLE R SQUARED..... .321

Fall

ANALYSIS OF VARIANCE

Source of Variation	DF	Sums of Square	Mean Squares	F-Value
Intercept	1	3.670E0002	3.670E0002	
Regression	22	7.860E0002	3.573E0001	26.654
Type 1	7	1.426E0002	2.037E0001	15.198
Type 2	8	2.591E0002	3.239E0001	24.162
Type 3	7	2.270E0002	3.243E0001	24.192
Residuals	1239	1.661E0003	1.340E0000	
Total	1262	2.814E0003		

Table 9. Catch (t) per successful trip, number of nets fished per trip and CPUE index for spring and fall inshore gillnet fisheries of NAFO Division 4T.

YEAR	Spring Fishery			Fall Fishery		
	Catch (t) per successful trip[1]	Number of nets fished per trip[2]	CPUE index tons per net per trip	Catch (t) per successful trip[1]	Number of nets fished per trip[3]	CPUE index tons per net per trip
1973	2.09	21.0	0.10	2.66	7.1	0.37
1974	1.23	20.6	0.06	2.99	7.6	0.39
1975	1.29	30.1	0.04	3.63	7.2	0.50
1976	1.34	29.9	0.04	3.13	8.9	0.35
1977	1.89	27.9	0.07	3.56	9.3	0.38
1978	2.22	29.4	0.08	3.21	11.4	0.28
1979	1.49	34.4	0.04	1.78	11.9	0.15
1980	1.09	39.2	0.03	1.45	18.4	0.08
1981	0.92	41.4	0.02	2.15	19.3	0.11
1982	1.73	39.7	0.04	2.33	18.6	0.13
1983	1.79	22.5	0.08	3.45	7.3	0.47
1984	1.90	26.5	0.07	3.02	5.3	0.57
1985	1.81	27.2	0.07	4.59	5.2	0.88

1 - For combined Statistical Districts 11, 65, 66, 67, 73, 75, 78, 80, 82, and 92.
2 - For combined Statistical Districts 63, 64, 65, 66, 67, 68, 70, 73, 75, 76, 77, 78, 80, 82, 83, and 92.
3 - For combined Statistical Districts 63, 64, 65, 66, 67, 68

Table 10. Catch (t) per set for purse seiners in Areas 433-439 of NAFO Division 4T 1971-85. The 1971-79 data are taken from Winters and Moores (1980), recent data were summarized directly from logbooks.

YEAR	Catch (t) per set			Unweighted mean
	Sept.	Oct.	Nov.	
1971	47.2	59.4	63.6	56.7
1972	37.1	53.9	44.3	45.1
1973	49.1	--	--	--
1974	28.3	35.4	50.0	37.9
1975	32.1	37.8	33.5	34.5
1976	27.3	44.5	50.6	40.6
1977	39.5	53.1	40.6	44.4
1978	44.1	33.1	55.7	44.3
1979	31.3	19.9	22.2	24.5
1980	28.3	26.8	18.1	24.4
1981	--	22.2	46.2	34.2
1982	23.6	45.8	--	34.7
1983	--	33.4	71.0	52.2
1984	--	42.6	2.5	22.6
1985	--	53.6	101.5	77.6

Table 11. Biomass of herring at strata fished by research vessel E.E. Prince, 1970-85, in NAFO Division 4T (taken from D. Clay unpubl.).

Gulf herring TABLE: Biomass - tonnes EXP.TYPE: 1&2

YEARS / Stratum	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	No. Years	Mean Biomass	Stratum
415	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64807	0	16	4050	415
416	16266	18180	28096	51510	0	0	0	0	0	0	0	0	0	0	0	117736	16	14487	416
417	38762	11405	1164416	20872	681260	4171150	518813	1605333	0	0	9124	11405	0	13418	0	10862	16	516051	417
418	243262	16303	6149946	706293	79886	57061	362507	3733130	0	48052	45649	9510	16167	224663	163032	956457	16	800745	418
419	230968	24059	543454	18331	1424304	0	942239	157250	866131	63032	40521	177198	129574	94821	477334	37578	16	326675	419
420	1395616	1791205	1628630	792315	4026251	38939	6671707	160213	253302	237312	24878	27988	395119	972037	11052780	8390383	16	2366167	420
421	1214332	1683551	1432607	1397665	15047	109590	0	649741	224625	263895	30177	0	32699	79909	3481273	1008089	15	726451	421
422	8388190	15153237	3193836	647223	389471	13961559	1035001	931444	288261	453262	1139463	28826	294729	0	2791153	9632059	16	3645482	422
423	2511192	0	379779	0	97902	0	0	0	0	0	77506	0	73427	0	0	136189	16	204750	423
424	379596	0	0	0	0	0	0	0	54209	0	0	0	0	0	24011	0	15	28613	424
425	6410	0	0	0	18248	0	0	0	0	0	0	0	0	0	0	57625	15	5143	425
426	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10703	221023	16	14483	426
427	0	9916511	0	0	0	0	0	0	0	0	0	0	0	0	0	41319	16	622364	427
428	515189	0	0	0	0	0	43882	0	75136	0	0	0	0	0	0	0	15	39638	428
429	3878873	4961336	422302	0	0	457135	780540	1103866	0	0	49125	0	54583	54583	15530488	13031028	15	2520241	429
431	870965	964745	0	328812	186538	0	4521171	3948973	0	0	48353	0	48353	135472	0	126550	15	698746	431
432	422809	0	0	323830	0	17437	0	0	60931	3086353	0	0	1150844	137661	206733	20687	15	339205	432
433	4467163	3170692	161932	6873398	0	43013	325995	416898	31646287	0	0	217330	0	0	7256476	2762319	15	3583856	433
434	202457	150329	41267	43846	43846	0	41267	0	0	0	0	0	38974	0	57478	1979334	15	162425	434
435	74430	0	0	38193	210537	0	0	0	0	0	0	0	0	0	493426	138816	15	59713	435
436	9939	100997	0	0	0	0	0	0	0	0	0	0	0	0	16649	0	15	7974	436
437	8026	43991	0	0	16868	0	0	0	0	0	0	0	20483	0	0	13655	15	6439	437
438	14075	128810	0	0	0	0	0	0	0	0	0	0	0	8587	0	29197	15	11292	438
439	2592	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30674	15	2079	439
# Strata	13	24	24	24	24	24	24	24	22	24	24	24	24	23	24	24			# Strata
Biomass	24891131	38135331	15146265	11242488	7190158	18855884	15243122	12706848	33468882	4151906	1464798	472257	2254954	1721153	41626343	38741580		16707070	Biomass

NOTE: 1: 1970 strata 425, 431 to 439 missing
2: 1978 strata 424 and 428 missing
3: 1983 strata 421 missing

Table 12. Summary of samples taken for ageing of herring in NAFO Division 4T.

YEAR	Gillnet		Purse Seine	
	Spring	Fall	Spring	Fall
1971	2266	549	547	1046
1972	350	396	--	419
1973	1209	997	151	800
1974	1541	670	1074	1225
1975	3988	907	1934	621
1976	3067	696	1605	838
1977	1612	379	1559	2127
1978	5186	1462	896	2403
1979	7408	2258	1154	4204
1980	4850	194	1746	299
1981	2601	2245	95	549
1982	5240	1520	--	--
1983	878	2361	--	1102
1984	861	4077	--	2186
1985	457	999	--	437

Table 13. Proportion of spring (S) and fall (F) spawners sampled in the spring (prior to July 1) and fall fisheries in Areas 431-435, 436 and 437-439 of NAFO Division 4T, 1980-85.

Spring fishery

Area 431-435 Gillnet

	Numbers		%	
Year	S	F	S	F
80	4208	163	96	4
81	2755	73	97	3
82	3069	1	100	0
83	0	0	0	0
84	91	33	73	27
85	129	1	99	1

Area 436 Gillnet

	Numbers		%	
Year	S	F	S	F
80	941	0	100	0
81	382	74	84	16
82	369	0	100	0
83	590	48	92	8
84	18	2	90	10
85	242	3	99	1

Area 437-439 Gillnet

	Numbers		%	
Year	S	F	S	F
80	94	0	100	0
81	911	0	100	0
82	625	0	100	0
83	94	4	96	4
84	116	20	85	15
85	72	4	95	5

Fall fishery

Area 431-435 Gillnet

	Numbers		%	
Year	S	F	S	F
80	0	0	0	0
81	0	293	0	100
82	0	290	0	100
83	0	879	0	100
84	1	434	0	100
85	8	587	1	99

Area 436 Gillnet

	Numbers		%	
Year	S	F	S	F
80	3	191	2	98
81	1	639	1	99
82	0	73	0	100
83	8	166	5	95
84	3	386	1	99
85	1	25	4	96

Area 437-439 Gillnet

	Numbers		%	
Year	S	F	S	F
80	46	344	12	88
81	7	1931	0	100
82	28	1097	2	98
83	12	1074	1	99
84	37	812	4	96
85	49	314	13	87

Area 437-439 Purse

	Numbers		%	
Year	S	F	S	F
80	1235	474	72	28
81	84	443	16	84
82	0	0	0	0
83	507	488	51	49
84	521	318	62	38
85	206	207	50	50

Table 14. 1985 mean weights at age compared to average mean weights 1981-84 for spring and fall spawning herring in NAFO Div. 4T.

Weights at Age (in Kg)

Spring

Age	1981 Mean	1982 Mean	1983 Mean	1984 Mean	Mean 1981-1984	S.D.	1985 Mean	S.D.
2	.124	.117	.146	.144	.133	0.013	.105	.004
3	.173	.170	.178	.168	.172	0.004	.162*	.009
4	.232	.202	.214	.202	.213	0.012	.199*	.011
5	.277	.247	.242	.220	.247	0.020	.233*	.014
6	.318	.295	.252	.281	.287	0.024	.270*	.010
7	.346	.285	.310	.224	.291	0.044	.307*	.013
8	.366	.299	.254	.320	.310	0.040	.320*	.013
9	.376	.305	.398	.312	.348	0.040	.340	.021
10	.369	.312	.375	.241	.324	0.056	-	-
11+	.413	.420	.385	.216	.359	0.083	.379	.019

Fall

Age	1981 Mean	1982 Mean	1983 Mean	1984 Mean	Mean 1981, 83, 84	S.D.	1985 Mean	S.D.
2	.076	.094	.143	.137	.119	.030	-	-
3	.143	.151	.174	.214	.177	.029	.220*	.010
4	.242	.155	.249	.244	.245	.003	.271*	.012
5	.273	.189	.285	.290	.283	.007	.303*	.011
6	.317	.237	.317	.306	.313	.005	.351*	.011
7	.326	.324	.343	.344	.338	.008	.378*	.011
8	.348	.237	.362	.367	.359	.008	.395*	.013
9	.394	.285	.365	.380	.380	.012	.404*	.013
10	.328	.380	.348	.416	.364	.038	.423*	.009
11+	.427	.389	.398	.361	.395	.027	.444*	.013

* $P < 0.05$

Table 15. Weight (g)-at-age matrices for spring and fall fisheries of herring in NAFO Div. 4T.

WEIGHT AT AGE SPRING SPAWNERS 2/ 5/86

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	95	90	104	133	133	133	133	124	117	146	144	105
3 I	160	154	177	172	172	172	172	173	170	178	168	162
4 I	202	185	210	213	213	213	213	232	202	214	202	199
5 I	238	229	247	247	247	247	247	277	247	242	220	233
6 I	275	266	275	287	287	287	287	318	295	252	281	270
7 I	291	298	271	291	291	291	291	346	285	310	224	307
8 I	319	304	304	310	310	310	310	366	299	254	320	320
9 I	320	316	310	348	348	348	348	376	305	398	312	340
10 I	328	329	333	324	324	324	324	369	312	375	241	324
11+ I	348	357	353	359	359	359	359	413	420	385	216	379

WEIGHT AT AGE FALL SPAWNERS 2/ 5/86

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	47	40	35	119	119	119	119	76	94	143	137	119
3 I	126	115	111	177	177	177	177	143	151	174	214	220
4 I	190	169	184	245	245	245	245	242	155	249	244	271
5 I	235	215	217	283	283	283	283	273	189	285	290	303
6 I	255	248	253	313	313	313	313	317	237	317	306	351
7 I	283	272	276	338	338	338	338	326	324	343	344	378
8 I	314	288	283	359	359	359	359	348	237	362	367	395
9 I	327	314	300	380	380	380	380	394	285	365	380	404
10 I	331	325	323	364	364	364	364	328	380	348	416	423
11+ I	354	362	349	395	395	395	395	427	389	398	361	444

Table 16. Catch-at-age matrices for spring and fall spawning groups in the gillnet and purse seine fisheries of NAFO Div. 4T.

SPRING GILLNET CATCH 5/ 1/87

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	108	8	1	86	38	55	541	45	68	1	13	11
3 I	4911	14874	2338	13965	6459	7667	22219	13031	32597	5160	1877	4565
4 I	1974	3710	18058	3301	27332	3056	3567	7527	6047	29194	7932	8440
5 I	1191	1377	2307	3691	1386	20895	1406	1270	1475	3646	11970	9483
6 I	14032	1793	535	540	1902	556	9528	785	326	1019	1195	6487
7 I	2600	6672	97	42	315	1404	216	3197	177	36	52	1904
8 I	2272	1925	2946	59	262	110	1074	79	332	1	0	396
9 I	2532	1628	419	1084	96	63	104	285	113	1	0	271
10 I	338	2640	292	1	1361	362	140	38	1	1	0	31
11+ I	469	1660	2894	1497	1164	1672	2134	1009	109	1	0	121

SPRING PURSE SEINE CATCH 5/ 1/87

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	5152	1513	15930	3264	14395	21687	20841	6096	856	423	194	103
3 I	3824	12963	6159	44708	7662	6022	20360	4744	786	5662	1599	1806
4 I	1310	15119	9835	3572	37969	2800	2122	723	154	2012	3101	1922
5 I	456	1883	4439	6572	3706	13059	1690	34	1	288	1868	1888
6 I	7528	14450	1702	3023	5054	1574	6240	83	12	85	314	712
7 I	1099	13486	368	561	962	1668	3053	1247	40	34	64	244
8 I	1855	758	5858	439	921	596	959	675	6	49	11	75
9 I	3713	1767	615	5429	95	140	636	472	1	16	0	28
10 I	609	2817	1196	509	2223	357	180	70	1	1	0	22
11+ I	2060	4497	16959	11976	828	1815	776	189	1	9	34	17

FALL GILLNET CATCH 5/ 1/87

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	1	1	1	1	5	1	25	1	1	1	0	0
3 I	125	1	39	122	351	128	7254	6851	3542	792	931	1638
4 I	4258	1602	276	1879	4389	7809	3293	28863	18645	21648	26518	15901
5 I	1765	8163	1455	340	3104	3821	4027	5537	23280	10465	14918	22616
6 I	515	1227	5839	253	593	1883	929	2471	5308	12544	12214	11093
7 I	1876	742	465	3215	614	402	836	974	2250	2223	6236	6417
8 I	180	616	243	133	3440	484	185	830	960	1782	1308	3050
9 I	2070	403	419	81	83	694	210	104	491	589	446	317
10 I	730	315	50	468	178	11	139	53	131	81	154	289
11+ I	4813	1800	2143	1162	1785	1418	620	866	61	260	171	154

FALL PURSE SEINE CATCH 5/ 1/87

I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2 I	5402	95	92	204	1509	2905	1344	108	183	34	9	55
3 I	5590	2089	239	2915	18996	6088	25176	3223	5731	3990	204	1024
4 I	13265	2567	1482	5796	22990	27222	6702	4341	2881	2231	1001	1343
5 I	4332	17458	3579	3264	10988	23808	19251	434	2867	507	1330	2603
6 I	3721	5632	23106	3369	3380	9226	7414	135	355	1099	758	813
7 I	8790	2519	3690	18985	2851	1921	3294	3	93	186	482	497
8 I	2647	4238	1606	2086	10412	2645	453	148	44	85	78	205
9 I	3374	1756	3091	1331	1524	4548	639	112	150	34	34	67
10 I	3564	3253	686	2293	712	691	181	55	1	34	0	4
11+ I	14296	18836	14308	15542	14474	8968	2346	6	101	49	3	92

Table 17. An index of effort used to estimate terminal fishing mortalities for the spring and fall spawning groups of herring in NAFO Division 4T.

YEAR	EFFORT INDEX*	
	Spring	Fall
1974	132	117
1975	208	72
1976	177	84
1977	73	65
1978	111	159
1979	212	316
1980	299	531
1981	314	1027
1982	187	789
1983	104	303
1984	70	310
1985	103	220

*Landings in the gillnet fishery (cross products of Tables 15 and 16) of each spawning group divided by CPUE index (Table 9) X 1000.

Table 18. 1985 gillnet landings (t) by mesh size in NAFO Div. 4T.

Mesh size (inches)	Spring Fishery	Fall Fishery
1.625	21	0
2.00	75	202
2.125	68	117
2.250	3720	44
2.31	14	9
2.375	1030	251
2.50	710	665
2.625	235	16861
2.75	79	2671
2.875	14	553
3.00	7	189
3.25	26	0

Table 19. Partial recruitment for the spring and fall components of the NAFO Division 4T herring fishery used in the current and past two assessments.

	Spring				Fall			
			Current				Current	
AGE	Ahrens 1985 a	Clay & Chouinard 1986	Selectivity	Used in Assessment	Ahrens 1985 a	Clay & Chouinard 1986	Selectivity	Used in Assessment
1	0	0	0	0	0	0	0	0
2	0	0	0	0.001	0	0	0	0.001
3	0.47	0.77	0.87	0.87	0.03	0.11	0.17	0.17
4	1.00	1.00	1.00	1.00	0.50	0.53	0.58	0.58
5	1.00	0.82	0.72	1.00	1.00	1.00	1.00	1.00
6	0.50	0.58	0.51	0.51	0.85	0.73	0.53	1.00
7	0.34	0.51	0.46	0.46	0.63	0.54	0.32	1.00
8	0.20	0.40	0.46	0.46	0.53	0.31	0.23	1.00
9	0.15	0.40	0.45	0.45	0.50	0.22	0.19	1.00
10	0.15	0.40	0.45	0.45	0.50	0.18	0.17	1.00
11+	0.15	0.38	0.45	0.45	0.50	0.19	0.16	1.00

Table 20. Results of VPA for spring spawning herring in NAFO Div. 4T. A terminal F of 0.30 was used.

FISHING MORTALITY

I		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	I	0.040	0.032	0.055	0.088	0.321	0.236	0.221	0.027	0.008	0.007	0.006	0.000
3	I	0.168	0.309	0.252	0.293	0.641	0.577	1.009	0.289	0.200	0.129	0.069	0.261
4	I	0.216	0.659	0.584	0.332	0.622	0.608	0.505	0.531	0.154	0.291	0.188	0.300
5	I	0.059	0.346	0.524	0.441	0.399	0.794	0.777	0.203	0.166	0.138	0.202	0.300
6	I	0.258	1.338	0.425	0.588	0.614	0.317	1.163	0.515	0.074	0.181	0.072	0.153
7	I	0.468	0.411	0.103	0.192	0.431	0.611	1.201	1.413	0.230	0.020	0.026	0.138
8	I	0.383	0.752	0.316	0.154	0.705	0.453	1.141	1.066	0.342	0.076	0.004	0.138
9	I	0.160	0.632	0.751	0.409	0.081	0.242	1.321	3.429	0.432	0.025	0.021	0.135
10	I	0.082	0.204	0.628	1.082	0.410	0.484	0.733	0.661	0.101	0.012	0.041	0.135
11+	I	0.082	0.204	0.628	1.082	0.410	0.484	0.733	0.661	0.101	0.012	0.041	0.135

POPULATION NUMBERS

I		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	I	130982	47494	290647	38198	45271	92821	97422	228539	109747	63818	33835	380000
3	I	52146	90831	33951	201431	22285	23981	42983	61992	167802	84107	50367	24410
4	I	15282	28947	48299	20824	106243	9747	11378	15685	40491	107830	58856	34540
5	I	27788	9497	13005	23488	11865	43408	4043	6447	8910	28639	68749	37903
6	I	83934	12428	5309	6131	11468	6766	13844	1704	4579	6135	21079	47052
7	I	7979	49515	4511	3161	2988	5089	2779	3221	949	3574	4513	15565
8	I	10868	3617	28068	3252	1699	1574	1818	722	998	664	2891	3413
9	I	39171	5435	1397	16064	2363	844	573	232	266	673	517	2215
10	I	11521	26771	2369	471	8732	1482	437	163	20	172	533	393
11+	I	30768	30206	31606	12449	4853	7200	3970	1812	1089	859	824	1022

Table 21. Results of VPA for fall spawning herring in NAFO Div. 4T. A terminal F of 0.25 was used.

POPULATION NUMBERS 26/ 5/86

	I	1974	1975	1976	1977	1978	1979	1980	1981	1982
2	I	42984	89906	139205	160638	72555	261804	197958	216346	280286
3	I	49578	30303	73522	113887	131334	58033	211717	160836	177031
4	I	198134	35420	22919	59944	90495	90020	41888	143996	122565
5	I	34450	146362	25227	17174	42133	49318	42005	25251	87850
6	I	19554	22689	96648	16099	10800	21744	15379	13328	15271
7	I	41411	12177	12369	52939	9904	5247	7751	5042	8554
8	I	11705	24253	7018	6368	23256	4973	2194	2609	3243
9	I	29351	7025	15465	4073	3206	6505	1241	1220	1252
10	I	29377	19105	3798	9485	2057	1172	583	249	803
11+	I	130708	110490	84787	57387	37580	17333	5404	2010	986

	I	1983	1984	1985
2	I	211345	86163	242762
3	I	229312	173003	70536
4	I	136550	183418	140616
5	I	80870	90191	125270
6	I	48267	56284	59140
7	I	7379	27173	34344
8	I	4883	3862	16168
9	I	1747	2308	1907
10	I	445	866	1455
11+	I	1206	979	1222

FISHING MORTALITY 26/ 5/86

	I	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
2	I	0.150	0.001	0.001	0.001	0.023	0.012	0.008	0.001	0.001	0.000	0.000	0.000
3	I	0.136	0.079	0.004	0.030	0.178	0.126	0.185	0.072	0.060	0.023	0.007	0.043
4	I	0.103	0.139	0.089	0.153	0.407	0.562	0.306	0.294	0.216	0.215	0.181	0.145
5	I	0.218	0.215	0.249	0.264	0.461	0.965	0.948	0.303	0.399	0.162	0.222	0.250
6	I	0.274	0.407	0.402	0.286	0.522	0.832	0.915	0.243	0.527	0.375	0.294	0.250
7	I	0.335	0.351	0.464	0.623	0.489	0.672	0.889	0.241	0.361	0.448	0.319	0.250
8	I	0.310	0.250	0.344	0.486	1.074	1.188	0.387	0.534	0.419	0.549	0.505	0.250
9	I	0.229	0.415	0.289	0.483	0.807	2.212	1.406	0.218	0.834	0.501	0.261	0.250
10	I	0.175	0.230	0.240	0.384	0.639	1.050	0.908	0.642	0.199	0.330	0.217	0.250
11+	I	0.175	0.230	0.240	0.384	0.639	1.050	0.908	0.642	0.199	0.330	0.217	0.250

Revised No.2

Table 22. Summary of historical population biomass and fishing mortalities for spring and fall spawning herring in NAFO Div. 4T.

YEAR	SPRING SPAWNERS		FALL SPAWNERS	
	4+ Biomass (t)	4+ Fishing Mortality	5+ Biomass (t)	5+ Fishing Mortality
1971	86,900	0.27	220,000	0.63
1972	103,700	0.15	140,000	0.42
1973	81,700	0.20	99,000	0.28
1974	65,300	0.22	77,000	0.25
1975	47,800	0.56	78,000	0.25
1976	36,700	0.49	55,000	0.37
1977	24,000	0.40	42,000	0.48
1978	35,200	0.59	29,000	0.65
1979	19,800	0.70	20,000	1.01
1980	10,400	0.94	14,000	0.92
1981	8,200	0.67	12,000	0.29
1982	12,800	0.16	18,000	0.42
1983	33,400	0.25	35,000	0.27
1984	35,300	0.17	44,000	0.26
1985	35,500	0.23	64,000	0.25

Table 23. Summary of projections for spring and fall spawning herring in NAFO Div. 4T. 1985-92.

a) Spring Spawners

SUMMARY OF PROJECTIONS 6/ 1/8

YEAR	I	1985	1986	1987	1988	1989
POPULATION NUMBERS	I	296703.00	303874.89	304558.58	313129.31	317872.10
POPULATION BIOMASS	I	45557.96	45830.06	46666.10	47946.75	48800.49
CATCH	I	8680.57	9700.01	7541.92	8065.51	8281.36
F OR QUOTA	I	8680.57	9700.00	0.30	0.30	0.30

YEAR	I	1990	1991	1992
POPULATION NUMBERS	I	319065.15	316889.51	318481.82
POPULATION BIOMASS	I	49160.41	48349.98	48732.37
CATCH	I	8344.19	8237.48	8289.60
F OR QUOTA	I	0.30	0.30	0.30

b) Fall Spawners

YEAR	I	1985	1986	1987	1988	1989
POPULATION NUMBERS	I	613522.00	579462.21	570601.76	541337.20	521343.74
POPULATION BIOMASS	I	130159.40	126638.76	121366.82	113471.43	107567.92
CATCH	I	21373.19	15300.00	23804.29	21488.43	19717.68
F OR QUOTA	I	21373.19	15300.00	0.30	0.30	0.30

YEAR	I	1990	1991	1992
POPULATION NUMBERS	I	508467.12	500508.34	494685.83
POPULATION BIOMASS	I	103591.20	101066.36	99090.09
CATCH	I	18524.66	17767.21	17174.33
F OR QUOTA	I	0.30	0.30	0.30

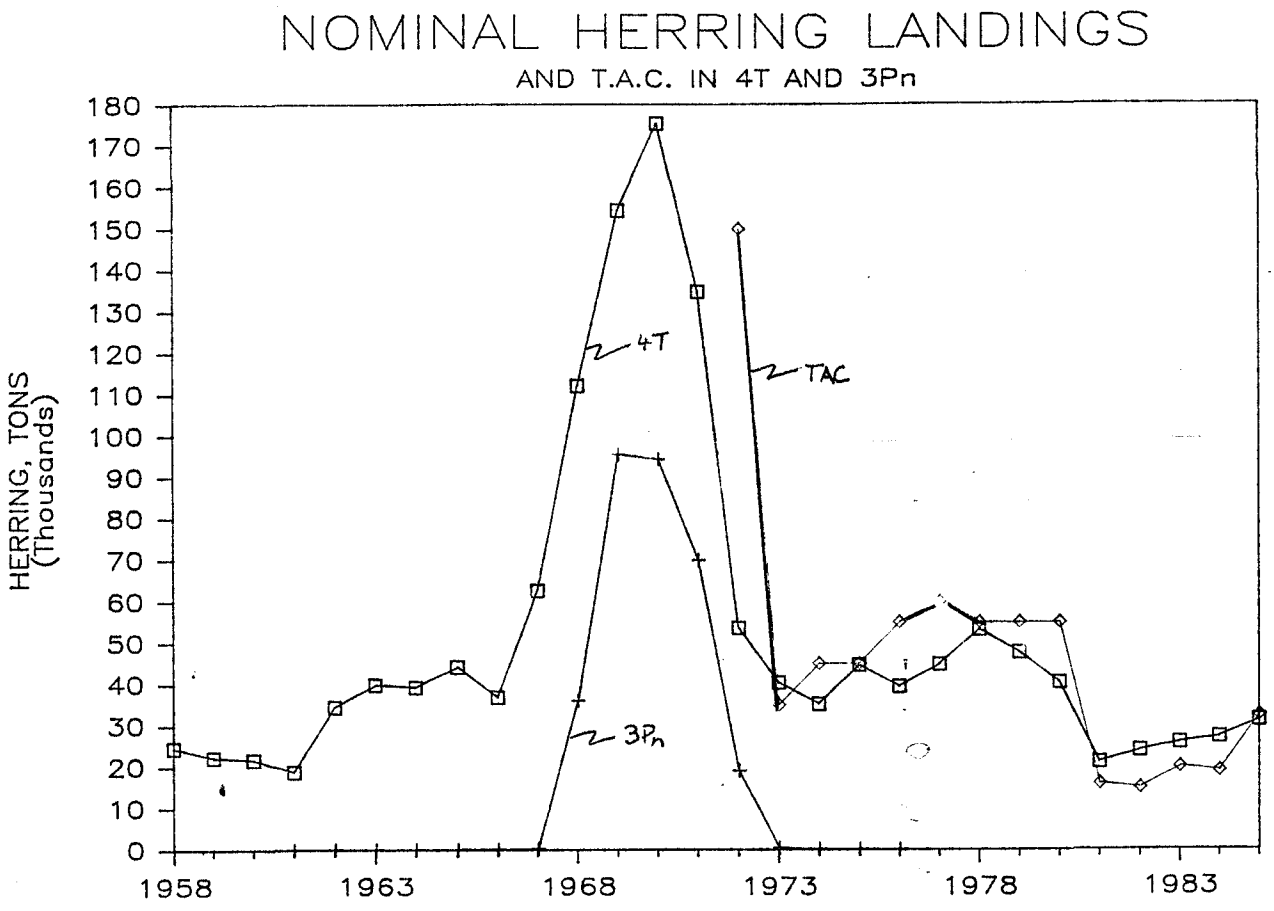
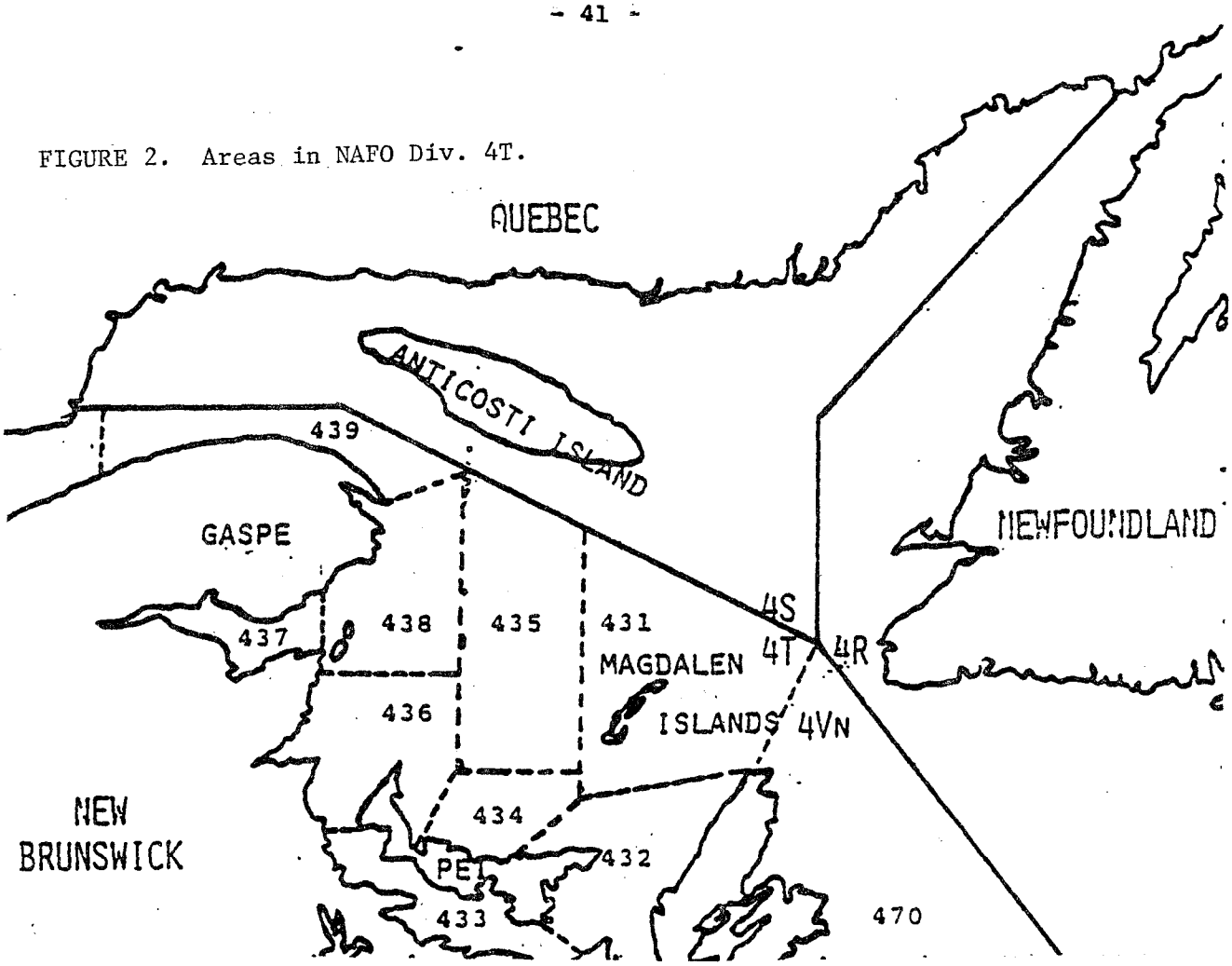


FIGURE 1. Landings of herring and TAC in NAFO Divisions 4T and 3Pn 1958-85.

FIGURE 2. Areas in NAFO Div. 4T.



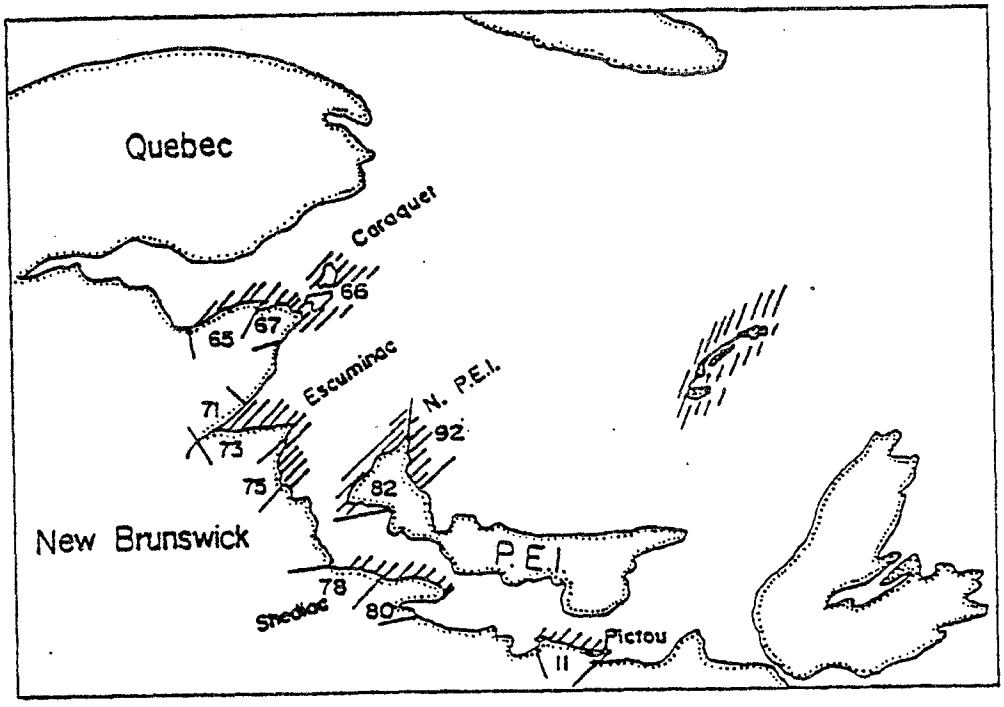


FIGURE 3. Map of southern Gulf of St. Lawrence showing the areas where the major gillnet landings are made each year, and for which catch rates were calculated.

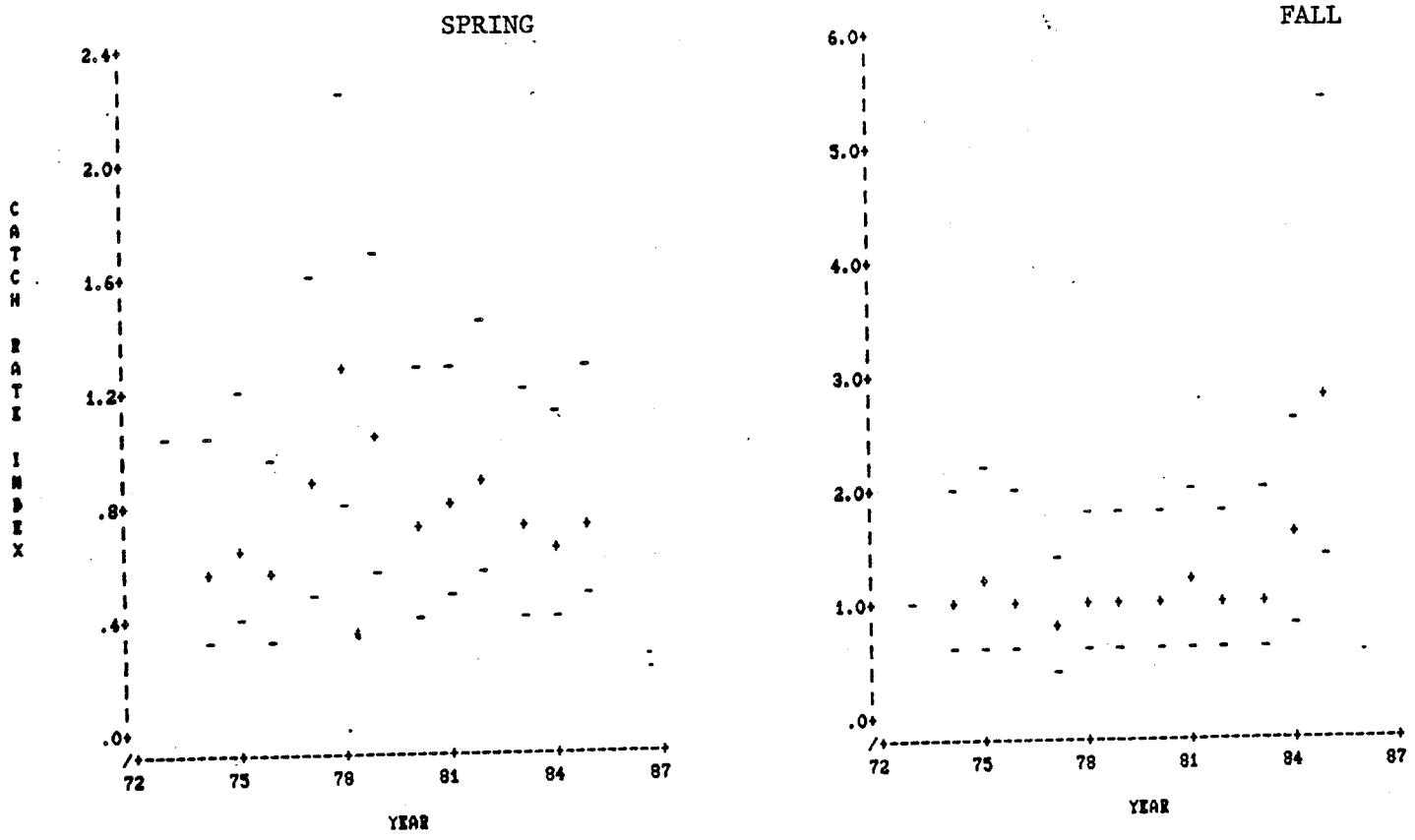


FIGURE 4. Standardized catch rates and their 95% confidence limits using monthly catch/trip data for spring and fall fisheries.

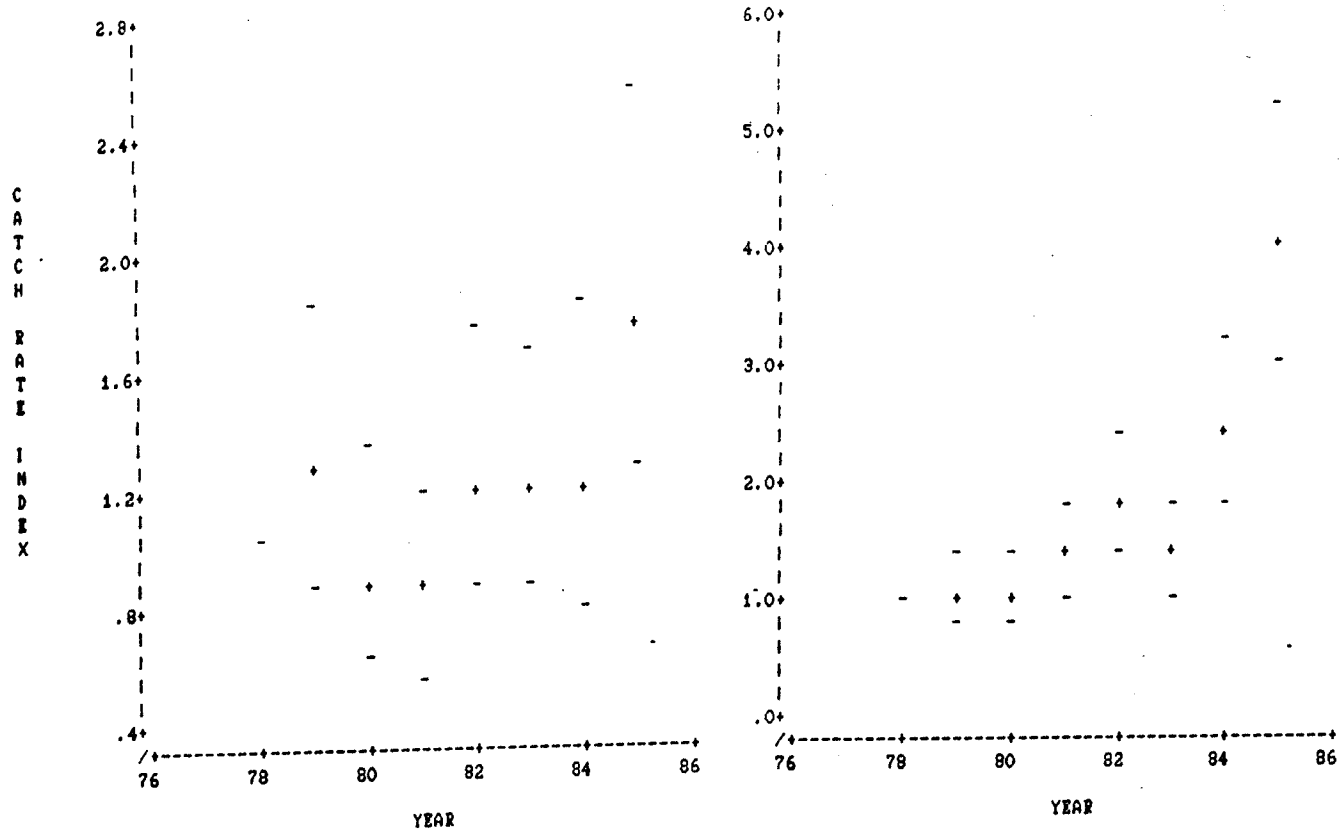
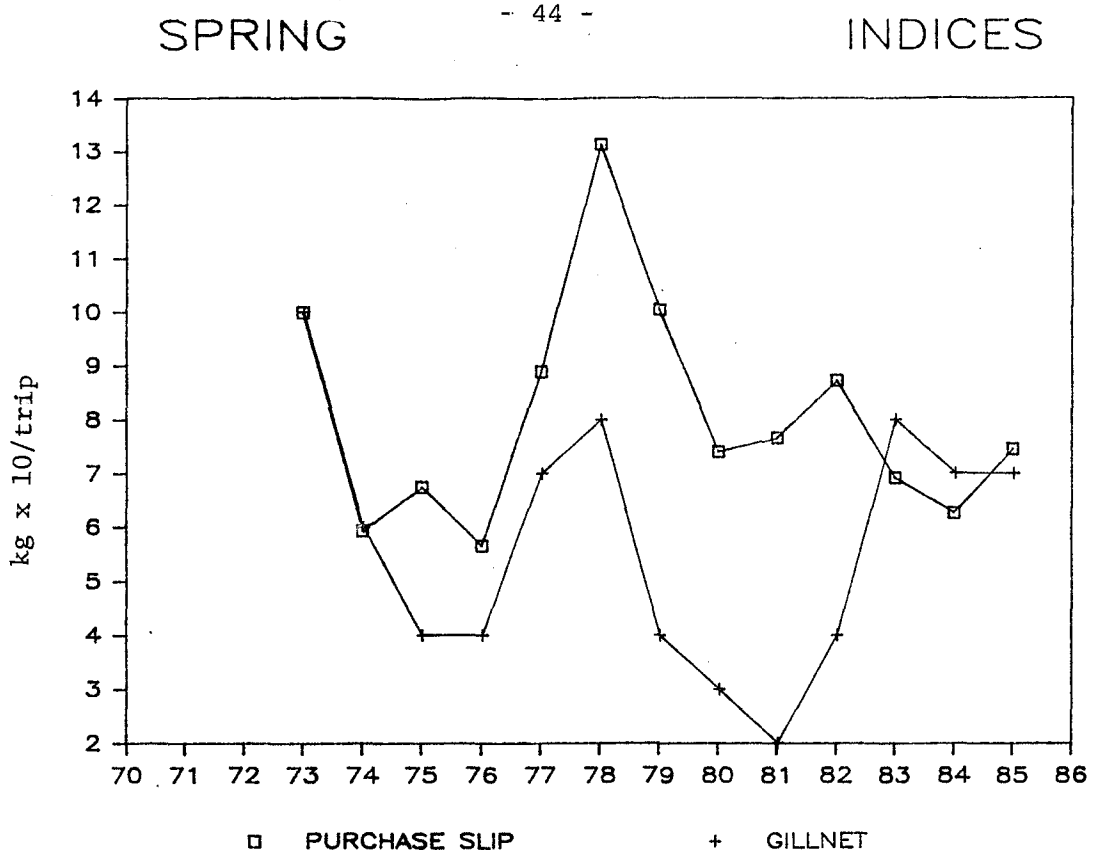


FIGURE 5. Standardized catch rates and their 95% confidence limits using daily catch/trip data for spring and fall fisheries.

a)



b)

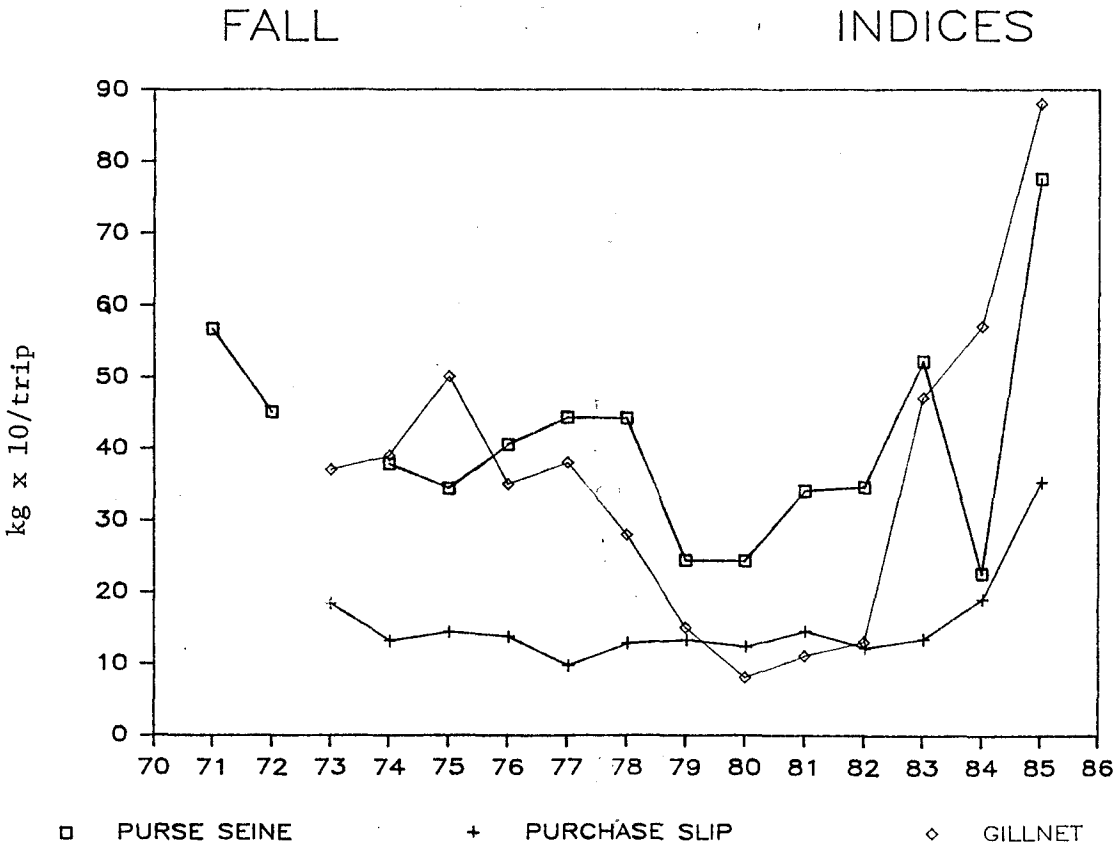
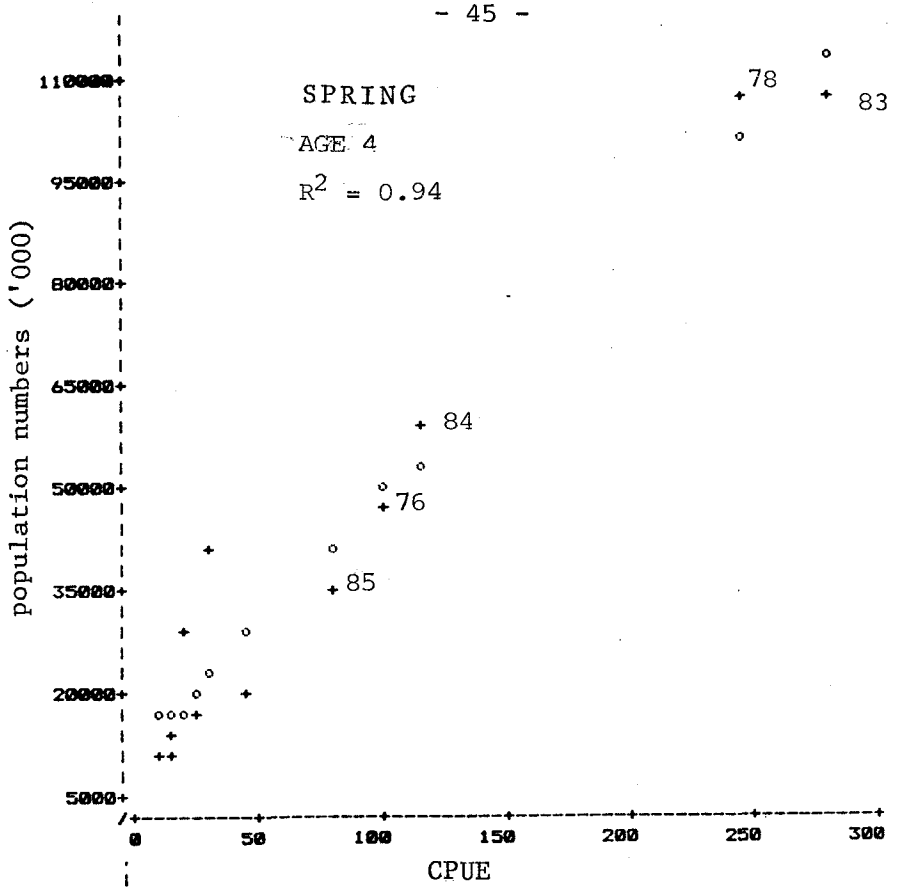


FIGURE 6. Standardized catch rate indices in spring a) and fall b) fisheries of herring in NAFO Division 4T.

a)



b)

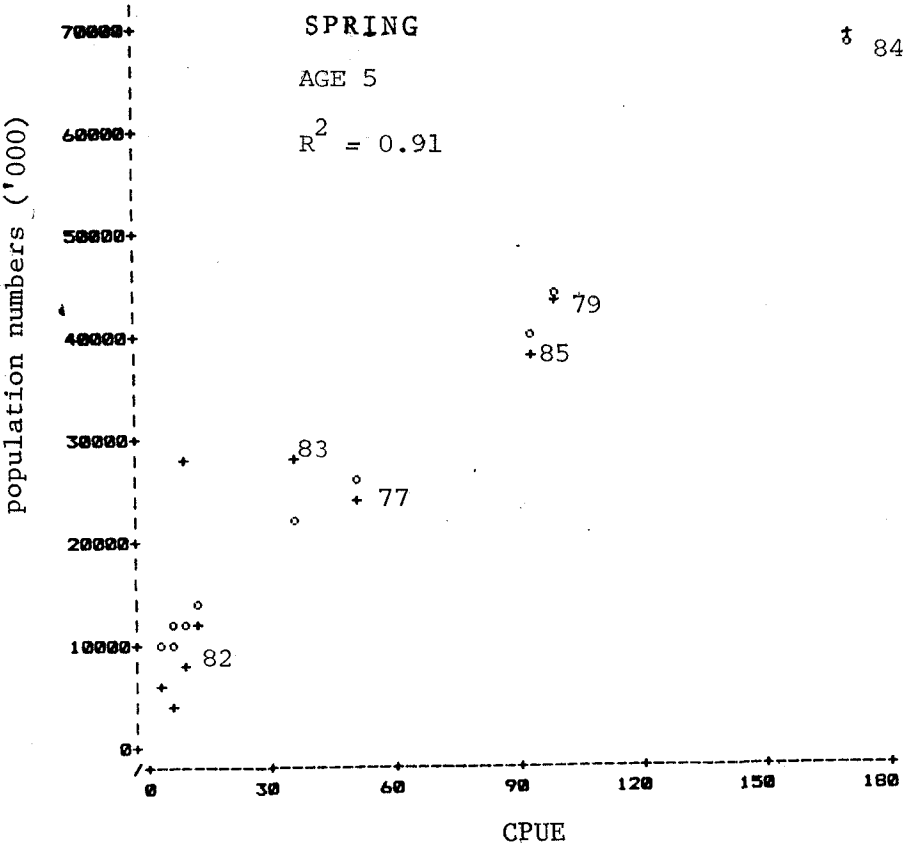
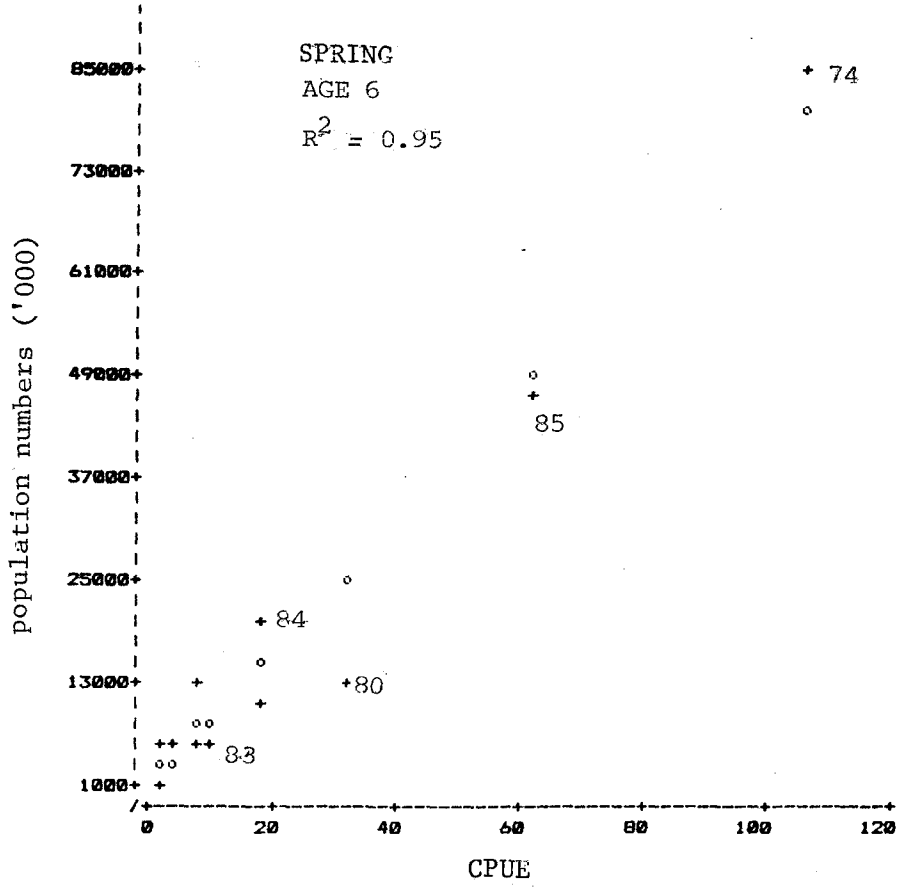
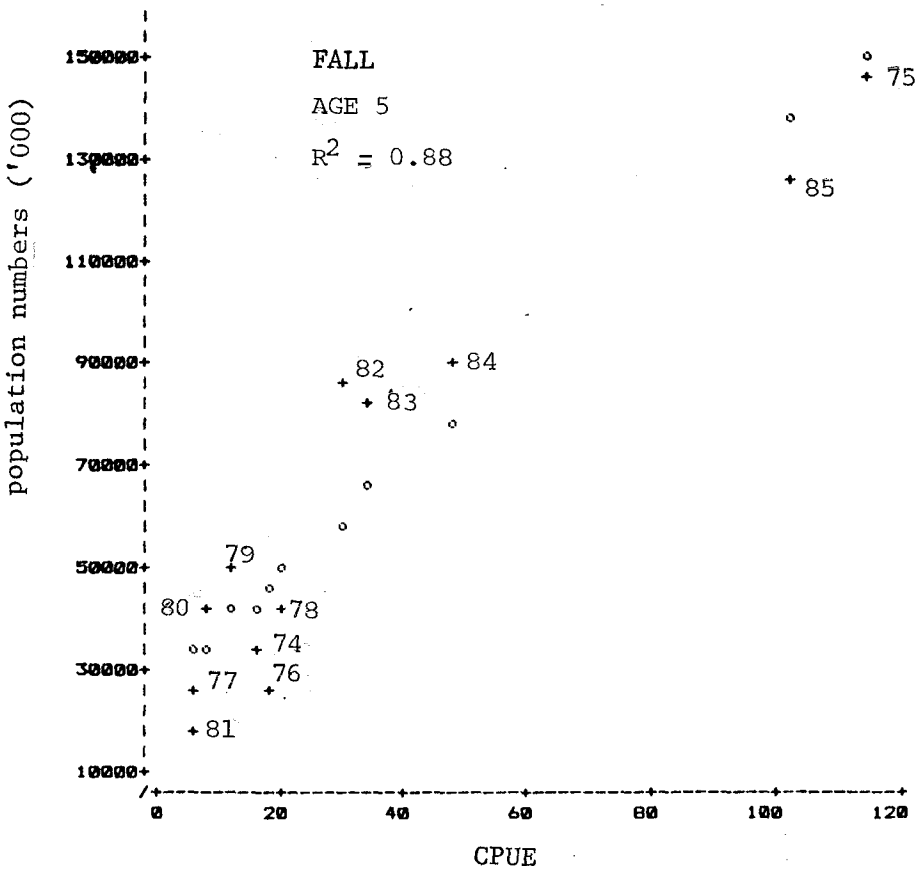


FIGURE 7. Calibration plots for spring spawners (F_t= 0.30) and fall spawners (F_t= 0.25). The abscissa is catch at age per unit effort in the gillnet fishery. The ordinate is population numbers at age from the VPA. Figures a,b,c are for spring spawners and d,e,f for fall spawners.

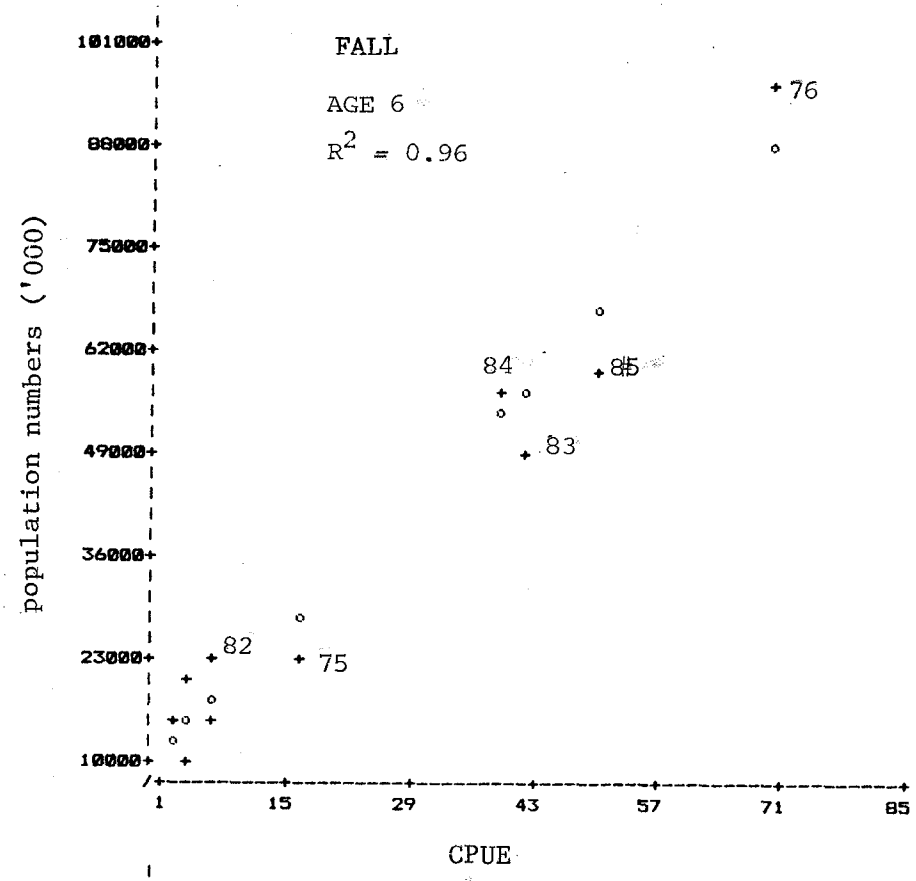
c)


SPRING
AGE 6
R^2 = 0.95
population numbers ('000)
85000
73000
61000
49000
37000
25000
13000
1000
0
20
40
60
80
100
120
CPUE
74
85
84
80
83

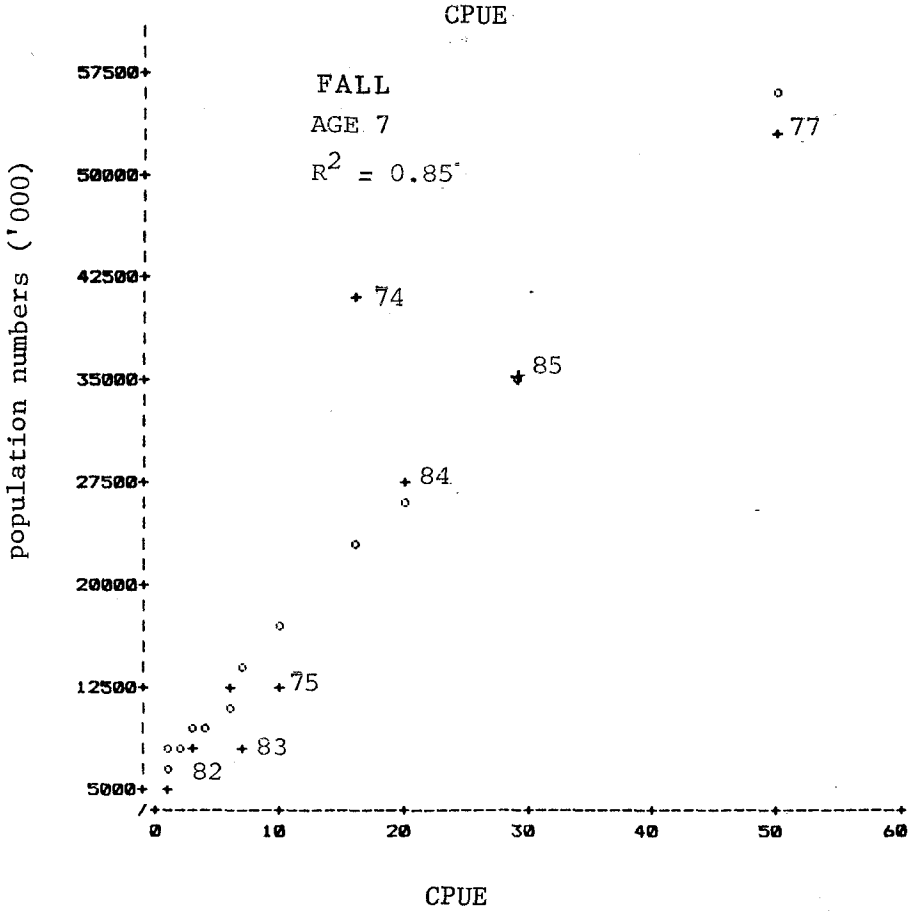
d)


FALL
AGE 5
R^2 = 0.88
population numbers ('000)
150000
130000
110000
90000
70000
50000
30000
10000
0
20
40
60
80
100
120
CPUE
75
85
82
84
83
79
80
78
74
77
76
81

e)


FALL
AGE 6
R^2 = 0.96
population numbers ('000)
101000
88000
75000
62000
49000
36000
23000
10000
1
15
29
43
57
71
85
CPUE
76
84
85
83
82
75

f)


FALL
AGE 7
R^2 = 0.85
population numbers ('000)
57500
50000
42500
35000
27500
20000
12500
5000
0
10
20
30
40
50
60
CPUE
77
74
85
84
75
83
82